



CERES FLASHFlux Status:

Near-Real Time Surface Radiative Fluxes and Meteorology for Research and Applications

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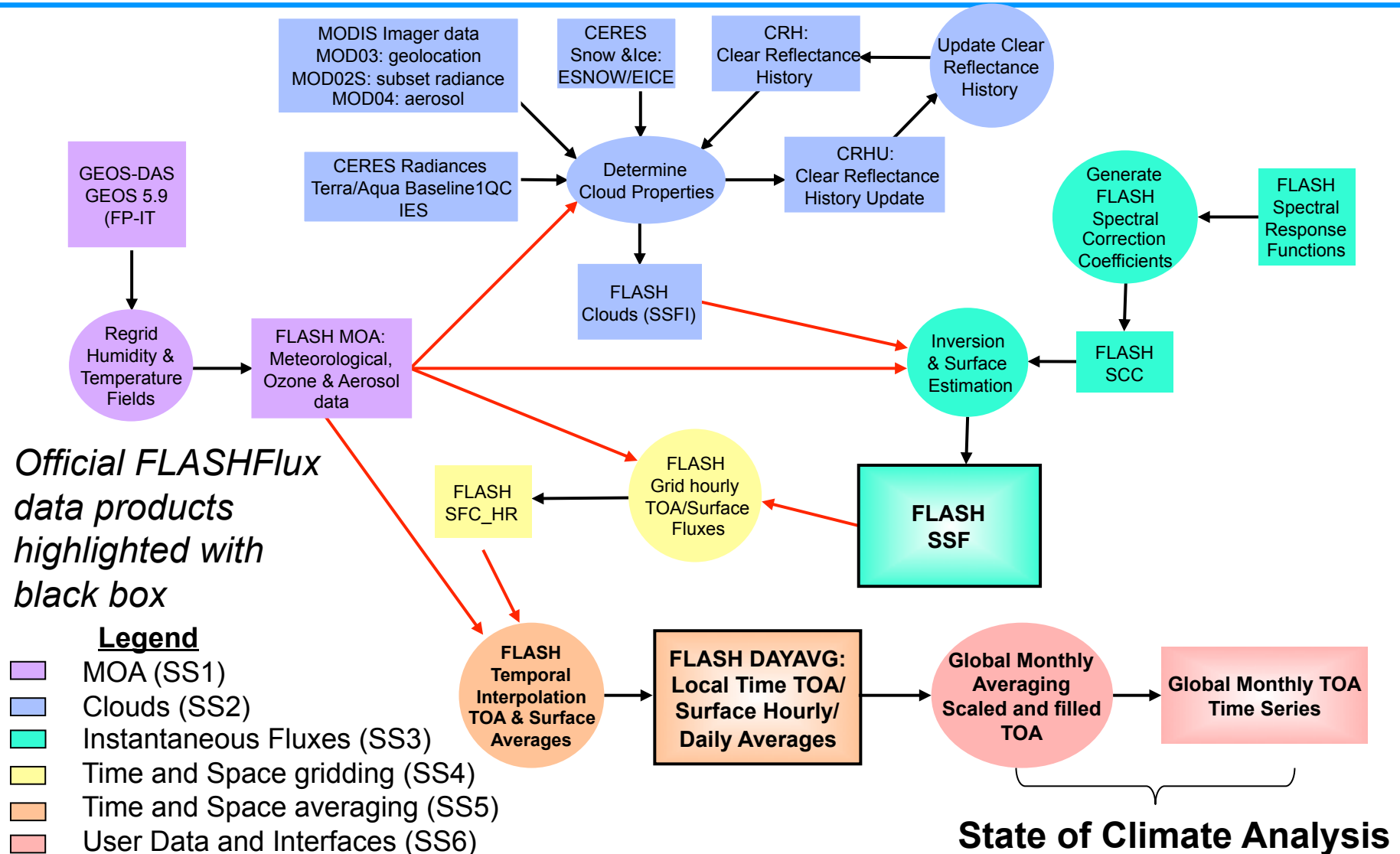


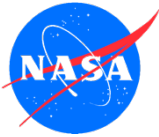
CERES FLASHFlux Overview

- ***FLASHFLUX = Fast Longwave And Shortwave Radiative Fluxes from CERES and MODIS***
 - ***FLASHFlux Objectives:***
 - Provide TOA and surface radiative fluxes within one week of observation for scientific and applied science uses:
 - Level 2 – SSF for Terra and Aqua; currently through 4/19/14
 - Level 3 – TISA, Terra+Aqua, 1°x1°; currently through 4/16/14
 - Scientific, Educational and Applied Science use examples:
 - CloudSat and Megha-Tropiques (SSF)
 - Annual “State of the Climate” report on radiative budgets (TISA)
 - CERES S’COOL, NASA Earth Observatory (TISA)
 - LaRC POWER (TISA): Building energy monitoring through (RETSCreen); Crop modeling systems such as APSIM (CSIRO)
 - Demonstrate processing system pushing data products to research and applications uses
 - Push subscription from ASDC to NASA Earth Observatory for Education
 - Pull from ASDC by CloudSat and Megha-Tropiques missions
 - Direct usage via DPO at NASA LaRC: CERES team, POWER
-



FLASHFlux Data Flow (v3A)






FLASHFlux SSF Data Products

FLASHFlux SSF Version 3A Products

Processed
through about
4/19/2014)

[https://
eosweb.larc.nas
a.gov/project/
ceres/flashflux-
l2_table](https://eosweb.larc.nasa.gov/project/ceres/flashflux-l2_table)

4/24/2014

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CERES Data and Information

The Clouds and the Earth's Radiant Energy System (CERES) is a key component of the Earth Observing System (EOS) program. The CERES instruments provide radiometric measurements of the Earth's atmosphere from three broadband channels. The CERES missions are a follow-on to the successful Earth Radiation Budget Experiment (ERBE) mission. The first CERES instrument (PFM) was launched on November 27, 1997 as part of the Tropical Rainfall Measuring Mission (TRMM). Two CERES instruments (FM1 and FM2) were launched into polar orbit on board the EOS flagship Terra on December 18, 1999. Two additional CERES instruments (FM3 and FM4) were launched on board EOS Aqua on May 4, 2002. The newest CERES instrument (FM5) was launched on board the Suomi National Polar-orbiting Partnership (NPP) satellite on October 28, 2011.

Spring 2014 CERES Science Team Meeting April 22-24, 2014 at NASA Langley Research Center Hampton, VA


Announcements

New CERES EBAF-TOA Ed2.8 product
Mar 26 2014
The CERES team has made an update to the version of the Energy Balanced and Filled (EBAF) Top-of-Atmosphere (TOA) data product from Edition 2.7 to read the full announcement... [View All](#)


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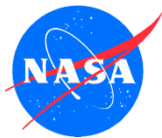
Instantaneous footprint-level (20km nominal) fluxes and cloud properties.

Processing Stream	Description	Data Products
SSF	CERES observed TOA fluxes, MODIS clouds and aerosols, and parameterized surface fluxes.	• SSF
CERES-MISR	MISR radiances associated with along-track CERES SSF data.	• CERES-MISR_MODIS
CCCM	CALIPSO/CloudSat cloud and aerosols collocated with nadir-view CERES fluxes and clouds.	• CCCM
FLASHFlux	Near real-time CERES observed TOA fluxes, MODIS clouds, and parameterized surface fluxes, not officially calibrated.	• FLASH_SSF
ERBElike	CERES instrument TOA fluxes using algorithms identical to those used by ERBE.	• ES8
CRS	Computed TOA/surface/profile fluxes using MODIS clouds and aerosols from SSF.	• CRS



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FLASHFlux TISA Data Products

**FLASHFlux TISA
Version 3A
Products
(Terra+Aqua;
Daily; 1°x1°
resolution;
Processed
through about
4/9/2014)**

**[https://
eosweb.larc.nas
a.gov/project/
ceres/flashflux-
tisa_table](https://eosweb.larc.nasa.gov/project/ceres/flashflux-tisa_table)**

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[Level 3B](#) [Level 3](#) [Level 2](#) [Level 1B](#) [Documentation](#)

Spatially (1°x1° lat/lon regional, 1° zonal, global) and temporally (daily, monthly, etc.) averaged fluxes and clouds.

Processing Stream	Description	Data Products
SYN1deg	CERES temporally interpolated TOA fluxes (GEO-enhanced), MODIS and GEO clouds, and computed TOA/surface/profile fluxes.	• SYN1deg
SSF1deg	CERES temporally interpolated TOA fluxes (constant meteorology) and MODIS clouds.	• SSF1deg
ISCCP-D2like	CERES-MODIS and GEO cloud properties stratified by ISCCP cloud types and in the similar D2 format.	• ISCCP-D2like
FLASHFlux	Near real-time CERES observed TOA fluxes, MODIS clouds, and parameterized surface fluxes, not officially calibrated.	• FLASH_TISA
ERBElike	CERES instrument TOA fluxes using algorithms identical to those used by ERBE. - ES4: Also includes large-scale regional, zonal, and global fluxes - ES9: Also includes 2.5° regional instantaneous fluxes	• ES4 • ES9
CRS	Computed TOA/surface/profile fluxes using MODIS clouds and aerosols from SSF.	• FSW




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Finding FLASHFlux from CERES Data Ordering Page (HDF Only)

**National Aeronautics and Space Administration**

SEARCH CERES

**CERES Data Products**

To subset, visually browse, and download CERES data products in netCDF format, click "Browse & Subset". For more information and documentation on a specific product, click on the "Data Product" name. Or as a quick reference, click on the ⓘ icon.

Access to the complete CERES archived HDF data products, [HDF Products](#)

Level 3B: Spatially (regional, global, etc.) and temporally (daily, monthly, etc) averaged fluxes where the net flux has been energy balanced.

Data Product (Information & Documentation)	Description	Parameter	Resolution	Version/Availability	Order Data
EBAF-TOA	Monthly and climatological averages of TOA clear-sky (spatially complete) fluxes, all-sky fluxes, and cloud radiative effect (CRE), where the TOA net flux is constrained to the ocean heat storage . Data Quality Summary	ⓘ	ⓘ	ⓘ	Browse & Subset
EBAF-Surface	Monthly and climatological averages of computed surface clear-sky fluxes, all-sky fluxes, and cloud radiative effect (CRE), consistent with the CERES EBAF-TOA fluxes. Data Quality Summary	ⓘ	ⓘ	ⓘ	Browse & Subset

Level 3: Spatially (regional, global, etc.) and temporally (daily, monthly, etc) averaged fluxes and clouds.


Data Product (Information & Documentation)	Description	Parameter	Resolution	Version/Availability	Order Data
SYN1deg	CERES geostationary (GEO) enhanced temporally interpolated TOA fluxes, MODIS and 3-hourly GEO cloud properties, MODIS aerosols, and computed TOA, surface and in-atmospheric (profile) fluxes consistent with the observed TOA fluxes, clouds and aerosols. Data Quality Summary	ⓘ	ⓘ	ⓘ	Browse & Subset
SSF1deg	CERES constant meteorology temporally interpolated TOA fluxes, MODIS clouds and aerosols. Data Quality Summary	ⓘ	ⓘ	ⓘ	Browse & Subset
ISCCP-D2like	CERES-MODIS and GEO daytime cloud properties stratified by ISCCP cloud types and in the similar D2 format. Data Quality Summary	ⓘ	ⓘ	ⓘ	Browse & Subset

Level 2: CERES instantaneous footprint level (20km nominal) fluxes and cloud properties.

Data Product (Information & Documentation)	Description	Parameter	Resolution	Version/Availability	Order Data
SSF	CERES observed TOA fluxes, MODIS clouds and aerosols, and parameterized surface fluxes. Terra Data Quality Summary ⓘ Aqua Data Quality Summary ⓘ	ⓘ	FOV*	ⓘ	Browse & Subset

*FOV: Field-of-View instantaneous footprint

Note: The Browse & Subset ordering tool will query for temporal and spatial resolutions.

**CERES**

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CERES Archived HDF Data Products

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Level 3B: Spatially (regional, global, etc.) and temporally (daily, monthly, etc) averaged fluxes where the net flux has been energy balanced.

Data Product (Information & Documentation)	Description	Parameter	Resolution	Availability	Order Data
EBAF-TOA	Monthly and climatological averages of TOA clear-sky (spatially complete) fluxes, all-sky fluxes, and cloud radiative effect (CRE), where the TOA net flux is constrained to the ocean heat storage . Data Quality Summary	ⓘ	ⓘ	ⓘ	Order via ASDC
EBAF-Surface	Monthly and climatological averages of computed surface clear-sky fluxes, all-sky fluxes, and cloud radiative effect (CRE), consistent with the CERES EBAF-TOA fluxes. Data Quality Summary	ⓘ	ⓘ	ⓘ	Order via ASDC

Level 3: Spatially (regional, global, etc.) and temporally (daily, monthly, etc) averaged fluxes and clouds.

Data Product (Information & Documentation)	Description	Parameter	Resolution	Version/Availability	Order Data
SYN1deg	CERES geostationary (GEO) enhanced temporally interpolated TOA fluxes, MODIS and 3-hourly GEO cloud properties, MODIS aerosols, and computed TOA, surface and in-atmospheric (profile) fluxes consistent with the observed TOA fluxes, clouds and aerosols. Data Quality Summary	ⓘ	ⓘ	ⓘ	Order via ASDC
SSF1deg	CERES constant meteorology temporally interpolated TOA fluxes, MODIS clouds and aerosols. Data Quality Summary	ⓘ	ⓘ	ⓘ	Order via ASDC
SYN/AVG/ZA/VG	CERES computed surface and in-atmospheric fluxes consistent and along with the CERES GEO enhanced temporally interpolated observed fluxes and clouds.	ⓘ	ⓘ	ⓘ	Order via ASDC
SRBAVG	CERES geostationary enhanced and constant meteorology temporally interpolated TOA fluxes, MODIS clouds and aerosols. Geo enhanced also contains parameterized surface fluxes .	ⓘ	ⓘ	ⓘ	Order via ASDC
FSW	Instantaneous footprint gridded means of flux and cloud parameters from the CRS product.	ⓘ	ⓘ	ⓘ	Order via ASDC
SFC	Instantaneous footprint gridded means of flux and cloud parameters from the SSF product.	ⓘ	ⓘ	ⓘ	Order via ASDC
ISCCP-D2like	Monthly 3-hourly (GMT based) and monthly mean cloud properties stratified by ISCCP cloud types and in the similar D2 format.	ⓘ	ⓘ	ⓘ	Order via ASDC
FLASH_TISA	Near real-time observed CERES TOA fluxes, MODIS clouds and aerosols, and parameterized surface fluxes. Not of climate quality or to be appended with any other CERES dataset.	ⓘ	ⓘ	ⓘ	Order via ASDC
ES4/ES9	Instantaneous gridded and monthly mean TOA fluxes using algorithms identical to those used by ERBE.	ⓘ	ⓘ	ⓘ	Order via ASDC

Level 2: CERES instantaneous footprint level (20km nominal) fluxes and cloud properties.

Data Product (Information & Documentation)	Description	Parameter	Resolution	Availability	Order Data
CRS	Computed TOA, surface and profile fluxes derived from the MODIS clouds and aerosols on the SSF.	ⓘ	FOV*	ⓘ	Order via ASDC
SSF	CERES observed TOA flux, MODIS clouds and aerosols and parameterized surface fluxes .	ⓘ	FOV*	ⓘ	Order via ASDC
CERES-MISR	Nadir view CERES-SSF/MODIS/MISR collocated parameters.	ⓘ	FOV*	ⓘ	Order via ASDC
CCCM	Nadir view CERES-SSF/MODIS/CALIPSO/CloudSat collocated parameters.	ⓘ	FOV*	ⓘ	Order via ASDC
FLASH_SSF	Near real-time CERES fluxes and clouds in the SSF format, Not of climate quality or to be appended with any other CERES dataset.	ⓘ	FOV*	ⓘ	Order via ASDC
ES9	CERES observed TOA fluxes using algorithms identical to those used by ERBE.	ⓘ	FOV*	ⓘ	Order via ASDC

*FOV: Field-of-View instantaneous footprint data.

4/24/2014

CERES Science



SSF Paper Published

APRIL 2014

KRATZ ET AL.

1059

The Fast Longwave and Shortwave Flux (FLASHFlux) Data Product: Single-Scanner Footprint Fluxes

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(Manuscript received 8 February 2013, in final form 19 September 2013)

ABSTRACT

The Clouds and the Earth's Radiant Energy Systems (CERES) project utilizes radiometric measurements taken aboard the *Terra* and *Aqua* spacecrafts to derive the world-class data products needed for climate research. Achieving the exceptional fidelity of the CERES data products, however, requires a considerable amount of processing to assure quality and to verify accuracy and precision, which results in the CERES data being released more than 6 months after the satellite observations. For most climate studies such delays are of little consequence; however, there are a significant number of near-real time uses for CERES data products. The Fast Longwave and Shortwave Radiative Flux (FLASHFlux) data product was therefore developed to provide a rapid release version of the CERES results, which could be made available to the research and applications communities within 1 week of the satellite observations by exchanging some accuracy for speed. FLASHFlux has both achieved this 1-week processing objective and demonstrated the ability to provide remarkably good agreement when compared with the CERES data products for both the instantaneous single-scanner footprint (SSF) fluxes and the time- and space-averaged (TISA) fluxes. This paper describes the methods used to expedite the production of the FLASHFlux SSF fluxes by utilizing data from the CERES and Moderate Resolution Imaging Spectroradiometer instruments, as well as other meteorological sources. This paper also reports on the validation of the FLASHFlux SSF results against ground-truth measurements and the intercomparison of FLASHFlux and CERES SSF results. A complementary paper will discuss the production and validation of the FLASHFlux TISA fluxes.

1. Introduction

Defining the radiative energy exchange at the top of the earth-atmosphere system and at the earth's surface has long been identified as critical to understanding climate processes (Sutcliffe and Ohring 1986; GCOS 2003) and remains an active focus of research (Stephens et al. 2012; Wild et al. 2013). The reflected shortwave (SW) and outgoing longwave (LW) fluxes at the top of the atmosphere (TOA) constitute the radiative energy exchange of the entire earth-atmosphere system driven by

the magnitude of the incoming total solar irradiance, while the surface energy budget constitutes the energy exchange between the atmosphere and the earth's surface driven by radiative, sensible, and latent heating processes. Accurate derivations of the TOA and surface radiative quantities allow for closure in the atmospheric radiative budget and improvement in the calculations of the inferred heat transports within the earth-atmosphere system. The LW and SW net surface fluxes affect the heating-cooling of the surface and thus provide bounds for sensible and latent heat fluxes, as well as estimates for the horizontal oceanic and atmospheric heat transport. Changes to the input energy into the surface systems affect short- and long-term weather- and climate-related processes (Fasullo and Trenberth 2008a,b). Changes to

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- **Published in the Journal of Applied Meteorology and Climatology in April issue.**
- **Highlights the production and validation of the FLASHFlux SSF data product.**
- **Compares well with CERES SSF data product.**
- **TISA paper in progress.**

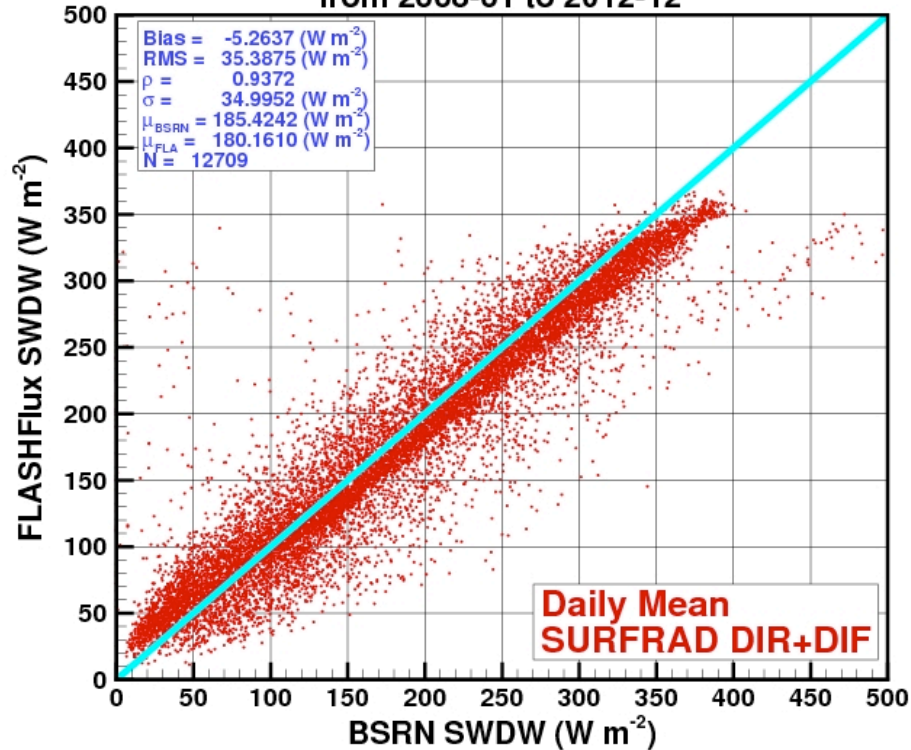


FLASHFlux TISA Validation

SW SURFRAD Measurements Only (2008-2012)

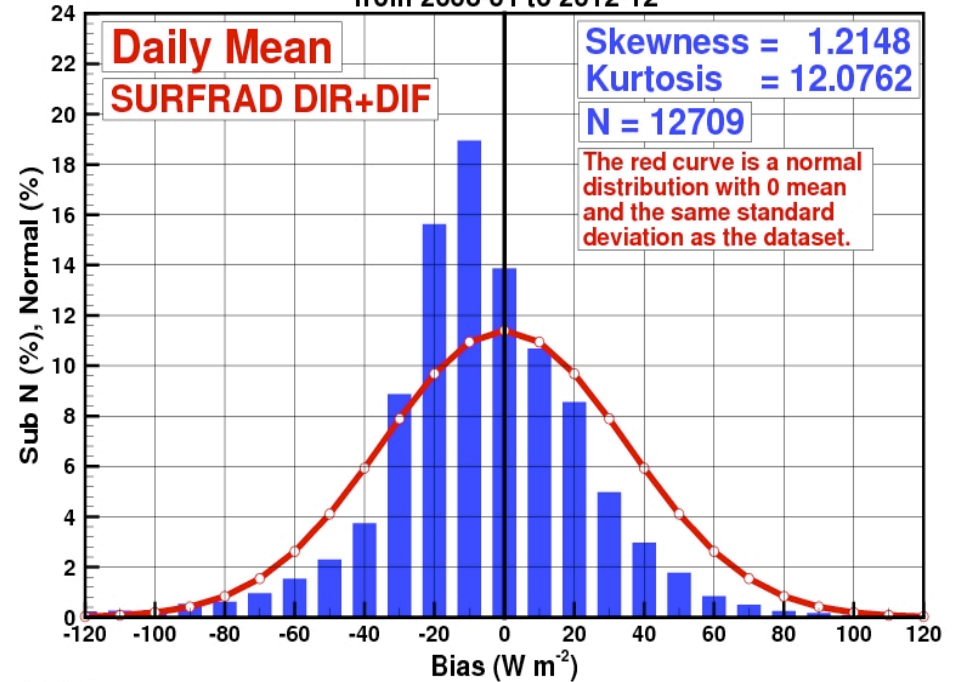
Version 2H

Comparison of FLASHFlux and BSRN Data
from 2008-01 to 2012-12



2014-04-19

Histogram of FLASHFlux-BSRN SWDW Differences
from 2008-01 to 2012-12



2014-04-22

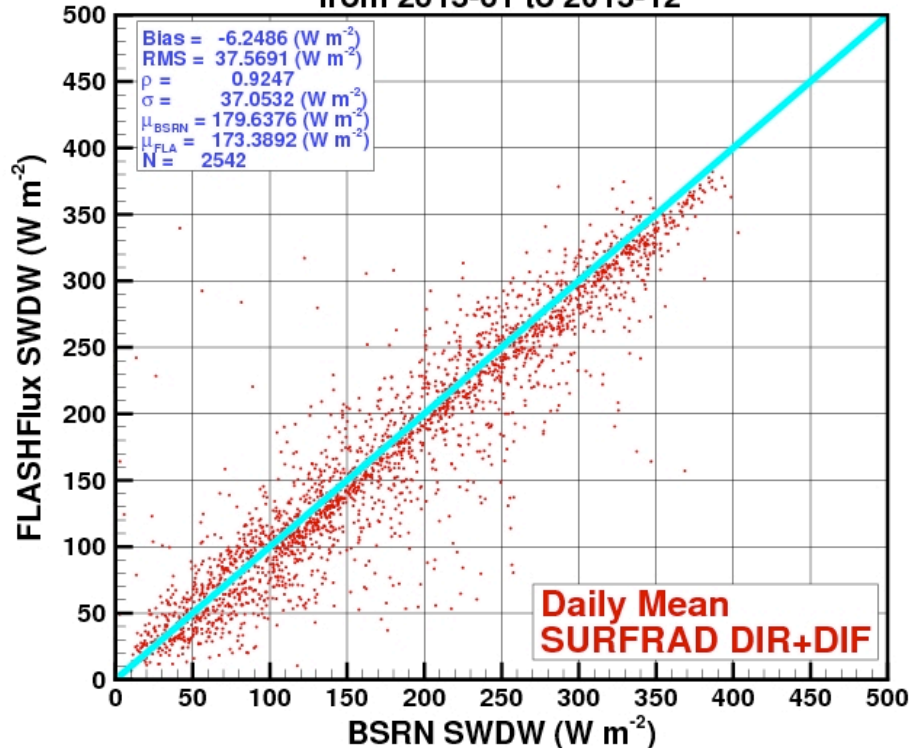


FLASHFlux TISA Validation

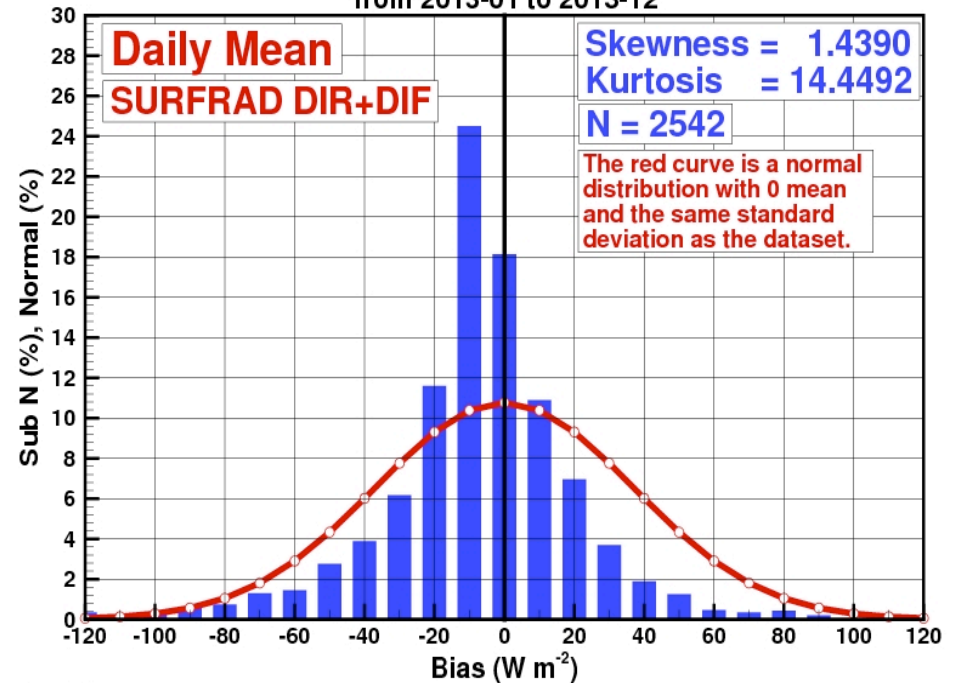
SW SURFRAD Measurements Only (2013)

Version 3A

Comparison of FLASHFlux and BSRN Data
from 2013-01 to 2013-12



Histogram of FLASHFlux-BSRN SWDW Differences
from 2013-01 to 2013-12



2014-04-22

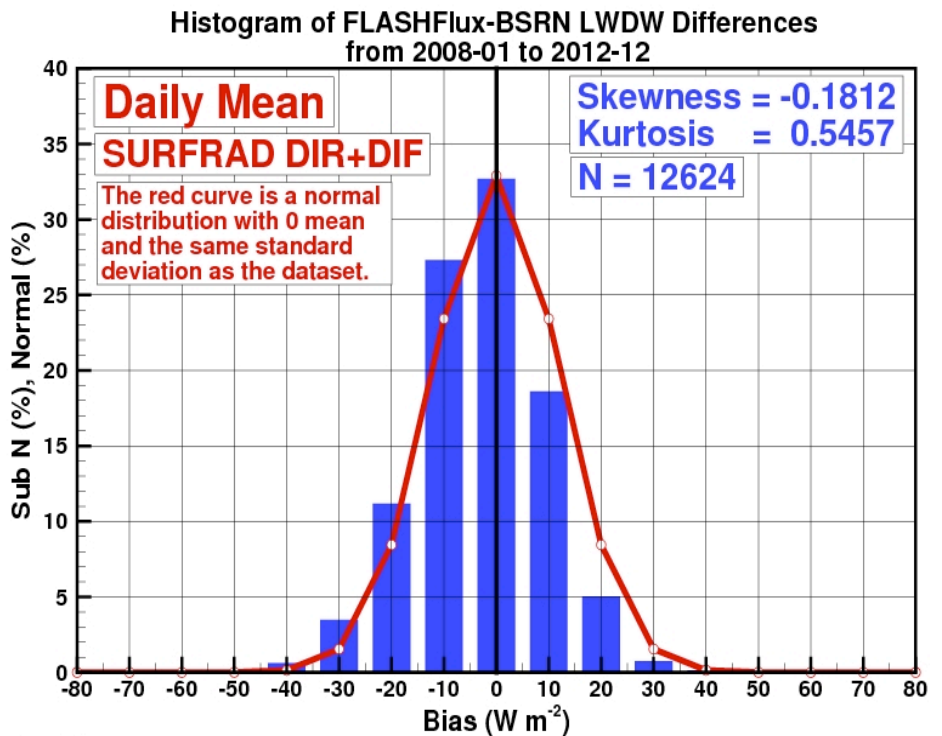
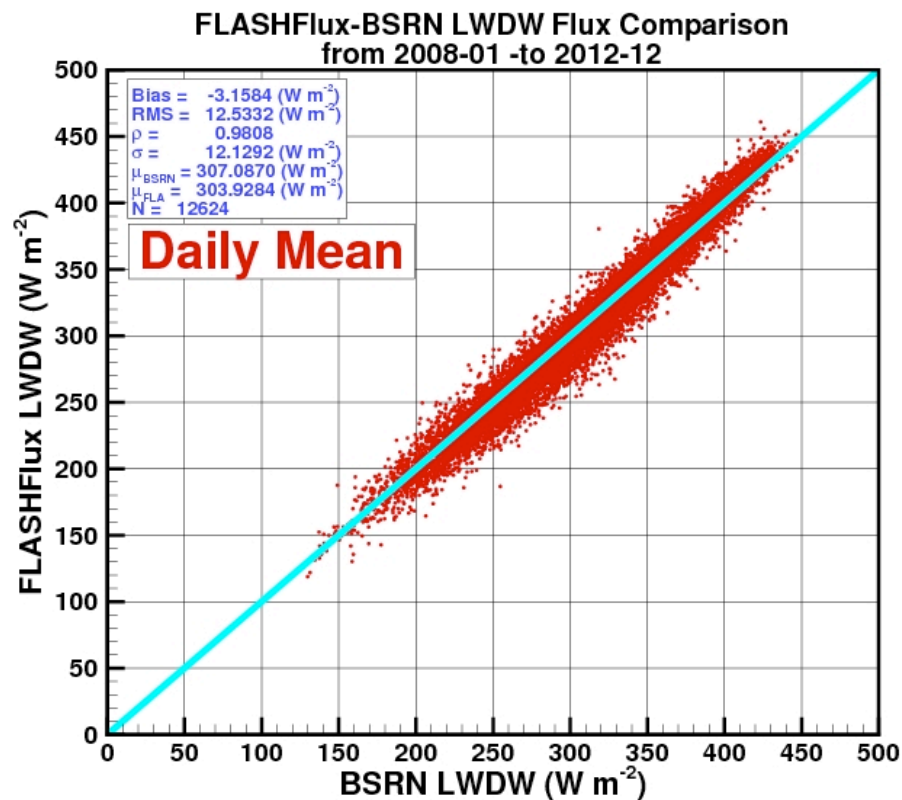
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FLASHFlux TISA Validation

LW SURFRAD Measurements Only (2008-2012)

Version 2H



2014-04-22

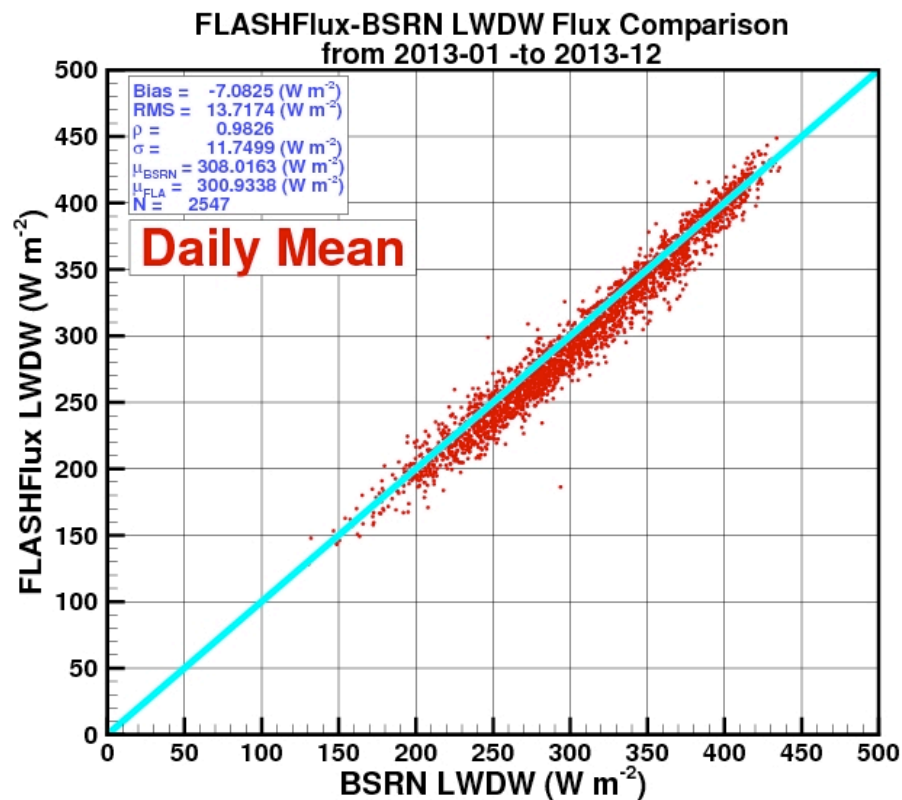
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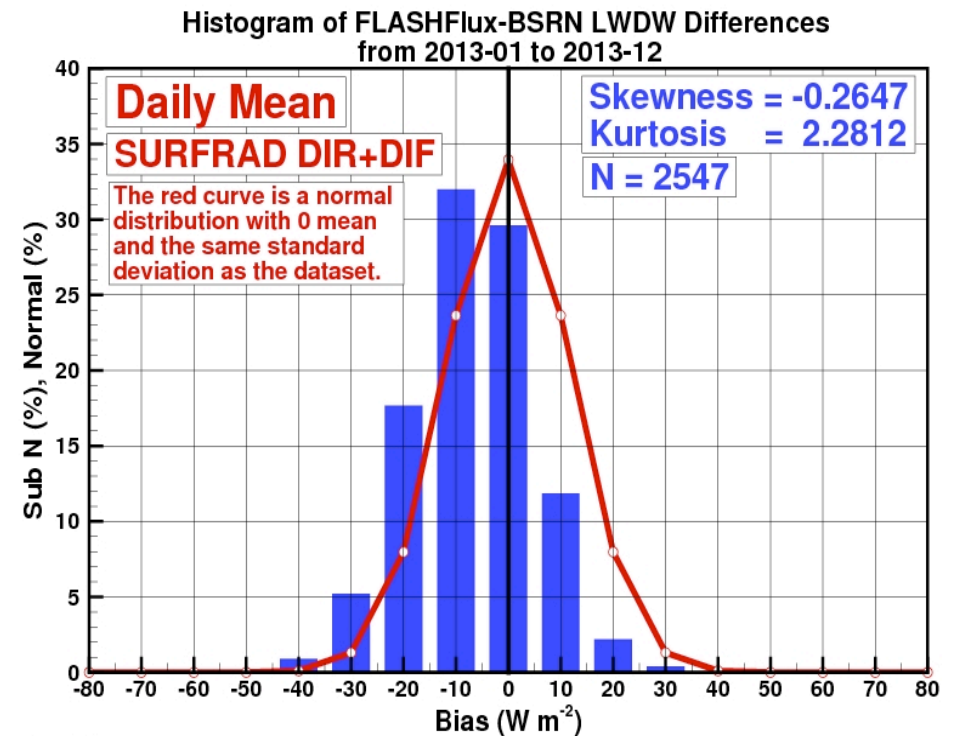
FLASHFlux TISA Validation

LW SURFRAD Measurements Only (2013)

Version 3A



2014-04-20

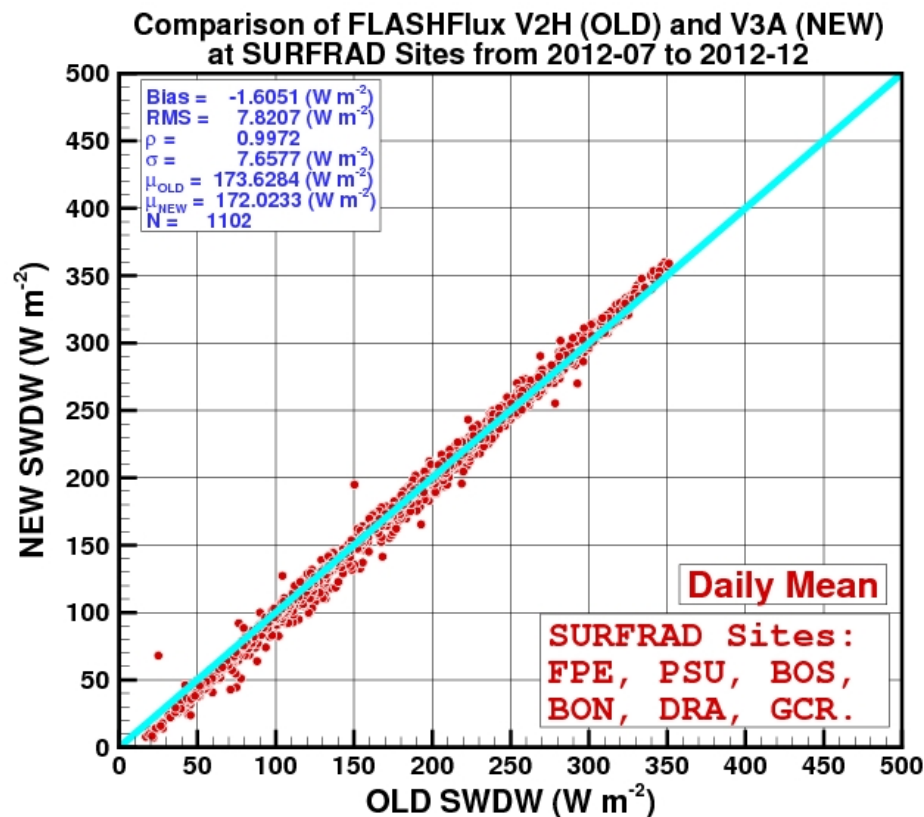


2014-04-22



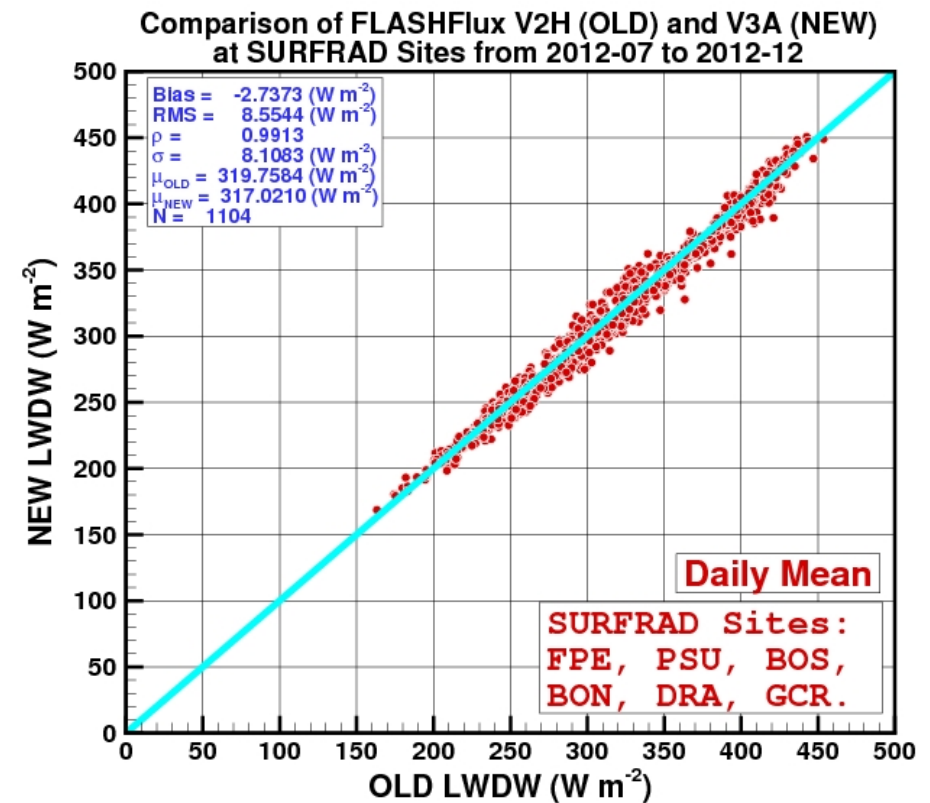
FLASHFlux TISA v2H v v3a

SW Surface Downward Flux



2014-04-24

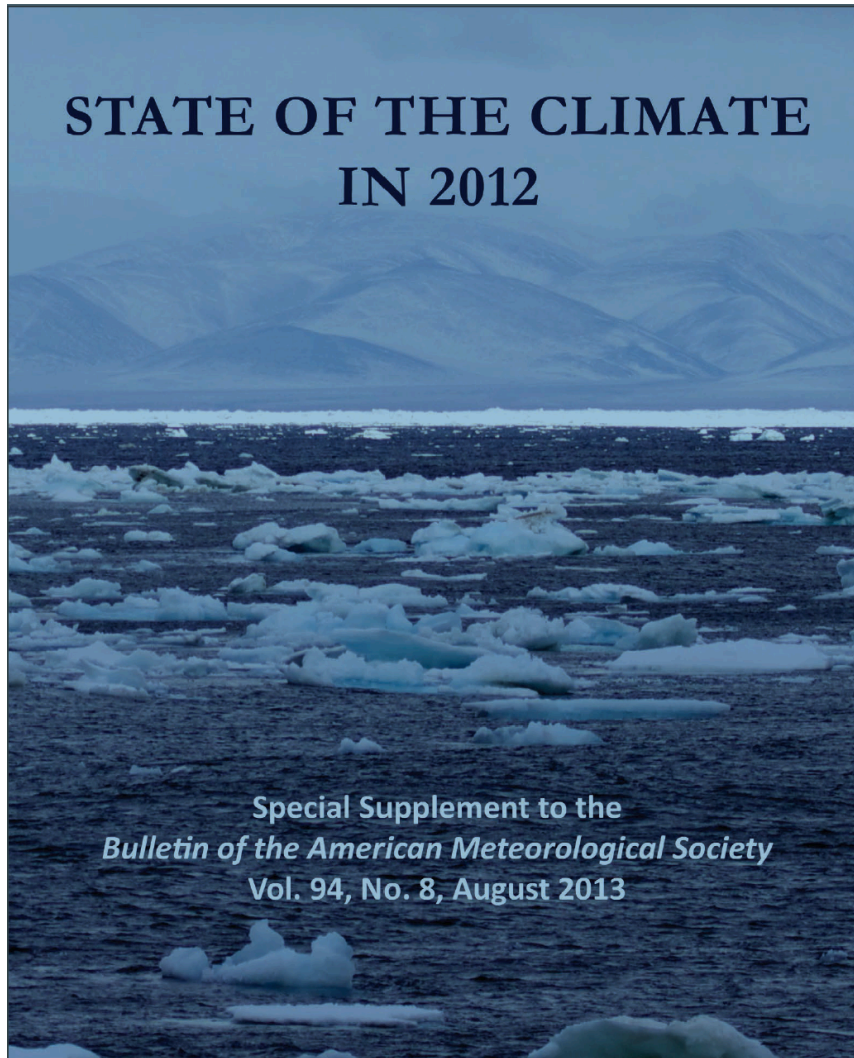
LW Surface Downward Flux



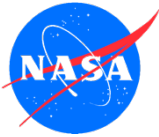
2014-04-24



State of the Climate 2012 Published



- *CERES FLASHFlux contributed to the special annual BAMS report on the “State of the Climate in 2012”.*
- *Issue appeared in Aug. 2013, providing estimates of changes in year to year Global Earth Radiation Budget for the first time.*
- *These data were extended and normalized relative to the CERES EBAF 2.6r products for this report.*

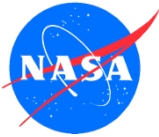


State of the Climate 2013 Analysis

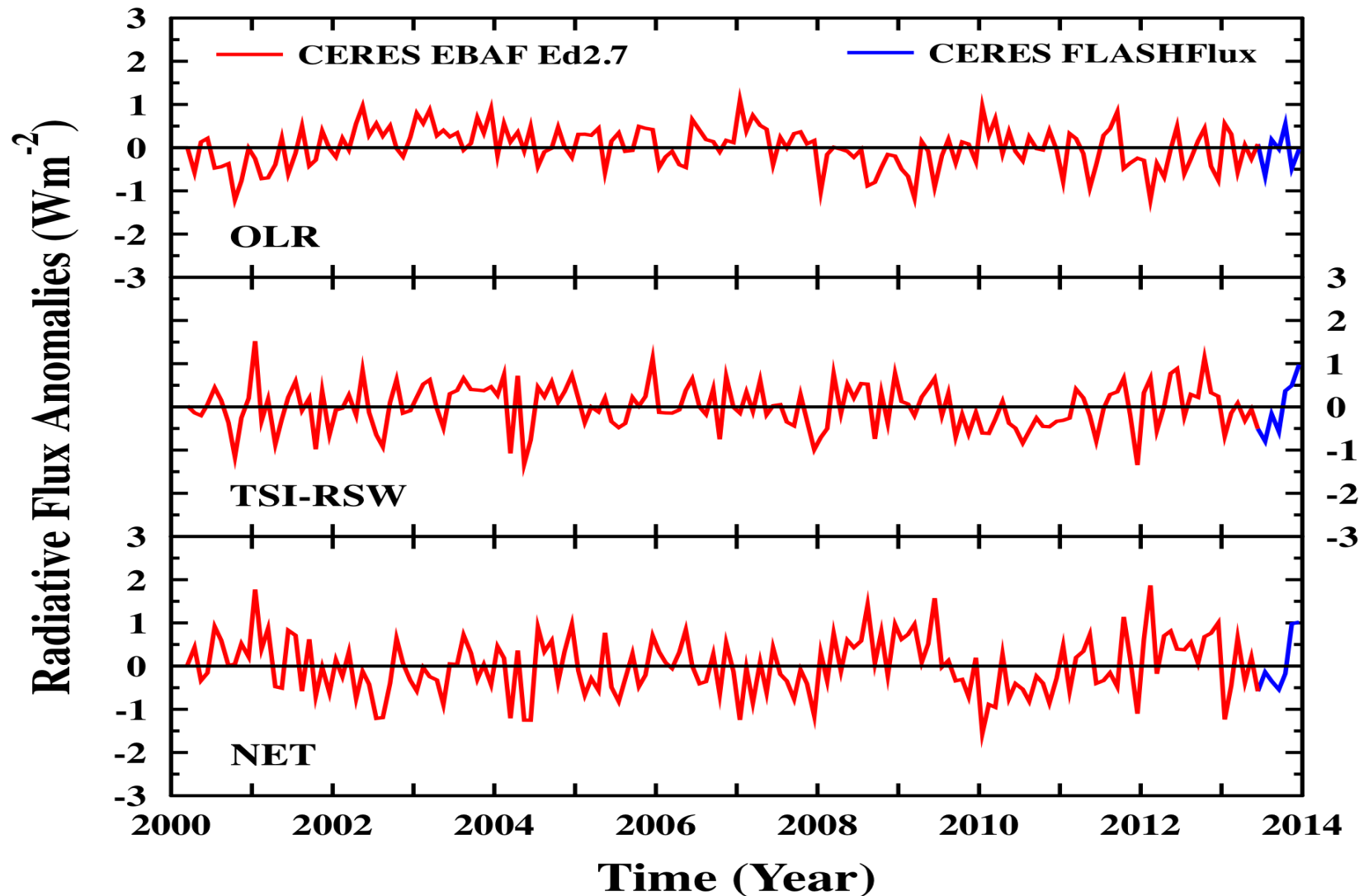
CERES FLASHFlux TOA flux variability for 2013 for BAMS “State of the Climate” report:

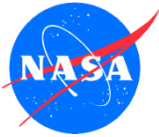
- TSI for SORCE had to be normalized relative to RMIB
- Overlap with EBAF from July 2012 to June 2013 used to adjust FLASHFlux TOA 3A fluxes
- 2σ monthly uncertainty (W m^{-2}) = ± 0.34 , ± 0.05 , ± 0.84 and $\pm 0.93 \text{ Wm}^{-2}$ for the OLR, TSI, RSW and NET radiation
- Global annual average anomalies and variability (in 2σ):

	One year change (2013 minus 2012) (Wm^{-2})	2013 anomaly (relative to climatology) (Wm^{-2})	Interannual variability (2001 to 2012) (Wm^{-2})
OLR	+0.25	-0.05	± 0.50
TSI	+0.00	+0.05	± 0.20
RSW	+0.45	+0.20	± 0.40
Net	-0.70	-0.10	± 0.70



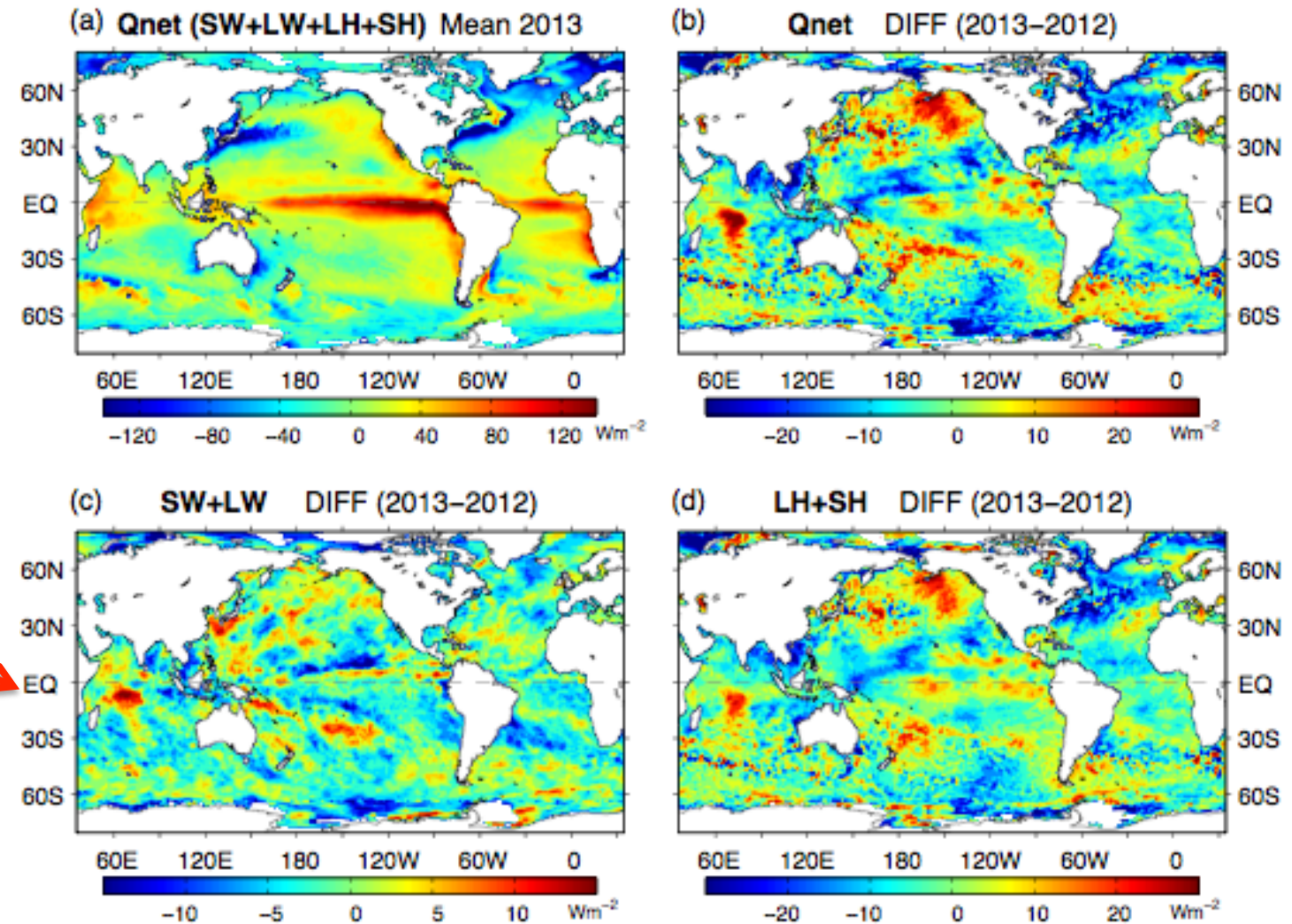
State of the Climate 2013 Analysis





Net Surface Flux Differences (2013-2012)

Lisan Yu
(WHOI),
OAFlux
With FLASH-
Flux net
surface flux
changes
2013-2012





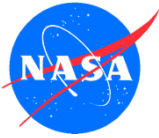
CERES FLASHFlux Agricultural Usage: CSIRO APSIM African Crop Modeling Project

APSIM (The Agricultural Production Systems sIMulator)

- internationally recognized as a highly advanced simulator of agricultural systems.
- DSSAT based formatted model
- Run for crop systems in West, East and Southern Africa
- FLASHFlux surface fluxes are “gold standard” of surface irradiance estimates for these regions (surface measurements are too poorly calibrated and/or maintained)
- Also uses surface temperature and other parameters from GEOS FP-IT



Results complements of John Hargreaves, CSIRO



CERES FLASHFlux Energy Usage: RETScreen Performance Plus

RETScreen Performance Plus (imbedded in RETScreen Suite)

- Internationally recognized for monitoring, targeting and verification of clean energy technologies in operational building systems
- Special ASCII time series format used for SW + meteorological parameters from GEOS FP-IT
- RETScreen reports at least 20,000 users worldwide with most using the NASA data sets from FLASHFlux production
- Example usage includes Weston Bakeries (Wonder Bread), Ford Motor Company, Property management firms, government buildings (i.e., NASA), etc.





Future Upgrades and Challenges

- ***Update to v3B***
 - Correct production code anomaly in SSF surface fluxes
 - Update calibration (working with CERES Instrument team)
 - Daily FF TISA TOA and surface fluxes to netCDF format to support inclusion in CERES subsetter (increase visibility)
- ***Continued refinement of algorithms:***
 - Improve near-real time surface albedo to reflect surface condition (support for ARISE – Arctic radiation experiment)
 - Aerosols: evaluation FP-IT compared to “Fast-MATCH”
- ***Future Upgrades***
 - CERES Ed 4 Clouds (MODIS Collection 6) and Inversion
 - Improve consistency between CERES algorithms and FLASHFlux (TISA/SYN)
 - Develop FLASHFlux NPP SSF data product stream
- ***Continued/improved support for applications (Solar industry, Agriculture, Building assessment)***



Summary and Conclusions

- ***FLASHFlux 3A***
 - Continuing production and validation
 - New version featuring netCDF delivered soon
 - Improving/upgrading algorithms will work with TISA team to increase similarity to current CERES products
 - Will coordinate with Clouds and Inversion teams to adapt to Ed 4
 - Plan to begin work on NPP SSF production system as new modules arrive
- ***FLASHFlux Applications:***
 - Expanding usage for Energy applications using RETScreen and other clean energy applications
 - Also noting expanded usage in building infrastructure risks applications
- ***FLASHFlux publications:***
 - SSF published; TISA paper next (renewable energy journal?)
 - 2013 SotC reports submitted



FLASHFlux Web Sites:

<http://flashflux.larc.nasa.gov>



Backup Slides



NASA LaRC CASI Analysis

- **NASA CASI:**

- NASA has instituted a Climate Adaptation Science Investigation (CASI) team to assess NASA building infrastructure risks to potential changes in climate
- Part of the assessment is a review of energy performance of buildings under varying meteorological conditions
- LaRC's team is assessing 4 buildings for team and with the intent to provide tutorial for other centers
- Analysis uses RETScreen Performance Plus tool
- Data sets from CERES FLASHFlux production allow computation of parameters to near-real time



CERES vs FLASHFlux TOA Fluxes

TABLE 1. Difference between the FLASHFlux and CERES LW TOA fluxes (FLASHFlux – CERES) for clear-sky and cloudy-sky conditions based on the *Terra* and *Aqua* measurements at the overpass times. The seven scene types are representative of the earth's surface and consist of subgroups derived from the 20 IGBP surface types. The first column represents the scene type. The second and fourth columns represent the systematic differences (bias) and the third and fifth columns represent the RMSs between the FLASHFlux and CERES model-derived fluxes for the clear- and cloud-sky cases, respectively.

<i>Terra</i> Type	Clear sky		Cloudy sky	
	Bias (W m^{-2}) (%)	RMS (W m^{-2}) (%)	Bias (W m^{-2}) (%)	RMS (W m^{-2}) (%)
Forest	-0.7 (-0.3)	1.1 (0.4)	-2.2 (-1.0)	6.2 (2.7)
Grassland	-1.2 (-0.4)	3.2 (1.1)	-2.3 (-1.0)	10.4 (4.4)
Cropland-urban	-0.9 (-0.3)	1.4 (0.5)	-2.4 (-1.0)	6.6 (2.9)
Bright desert	-3.1 (-1.0)	4.2 (1.4)	-2.1 (-0.8)	11.0 (4.2)
Tundra-barren	-1.6 (-0.5)	3.1 (1.0)	-1.9 (-0.8)	9.5 (3.9)
Water	-1.0 (-0.3)	1.4 (0.5)	-2.1 (-0.8)	5.4 (2.2)
Snow-ice	-2.4 (-1.3)	3.8 (2.1)	-1.7 (-0.9)	6.9 (3.8)

<i>Aqua</i> Type	Clear sky		Cloudy sky	
	Bias (W m^{-2}) (%)	RMS (W m^{-2}) (%)	Bias (W m^{-2}) (%)	RMS (W m^{-2}) (%)
Forest	-0.9 (-0.3)	1.3 (0.5)	-2.5 (-1.1)	6.8 (3.0)
Grassland	-1.5 (-0.5)	3.3 (1.1)	-2.7 (-1.1)	7.7 (3.2)
Cropland-urban	-1.1 (-0.4)	1.6 (0.6)	-2.7 (-1.2)	6.9 (3.0)
Bright desert	-3.4 (-1.1)	4.3 (1.4)	-2.7 (-1.0)	7.5 (2.8)
Tundra-barren	-1.8 (-0.6)	2.9 (1.0)	-2.7 (-1.1)	9.3 (3.7)
Water	-0.6 (-0.2)	1.0 (0.3)	-1.6 (-0.6)	4.6 (1.9)
Snow-ice	-1.4 (-0.8)	3.0 (1.8)	-1.7 (-1.0)	9.2 (5.1)

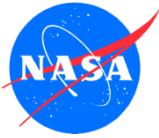


CERES vs FLASHFlux SSF TOA Fluxes

TABLE 2. As in Table 1, but for the SW.

<i>Terra</i> Type	Clear sky		Cloudy sky	
	Bias (W m^{-2}) (%)	RMS (W m^{-2}) (%)	Bias (W m^{-2}) (%)	RMS (W m^{-2}) (%)
Forest	-0.1 (-0.1)	1.7 (1.3)	0.7 (0.2)	6.3 (2.0)
Grassland	0.2 (0.1)	1.8 (1.0)	0.7 (0.2)	5.4 (1.7)
Cropland-urban	0.1 (0.1)	2.0 (1.3)	0.7 (0.2)	9.4 (3.0)
Bright desert	1.1 (0.4)	3.1 (1.0)	0.9 (0.3)	6.6 (2.1)
Tundra-barren	0.5 (0.3)	3.1 (1.4)	0.9 (0.3)	14.0 (5.3)
Water	-0.5 (-0.6)	2.3 (2.6)	0.0 (0.0)	5.8 (2.5)
Snow-ice	0.4 (0.1)	7.3 (2.7)	-0.7 (-0.3)	12.4 (4.6)

<i>Aqua</i> Type	Clear sky		Cloudy sky	
	Bias (W m^{-2}) (%)	RMS (W m^{-2}) (%)	Bias (W m^{-2}) (%)	RMS (W m^{-2}) (%)
Forest	-1.2 (-1.0)	3.9 (3.0)	-3.6 (-1.2)	7.2 (2.3)
Grassland	-2.6 (-1.5)	3.2 (1.8)	-3.8 (-1.3)	6.2 (2.1)
Cropland-urban	-2.3 (-1.4)	3.6 (2.3)	-3.7 (-1.2)	6.9 (2.2)
Bright desert	-3.9 (-1.2)	4.1 (1.3)	-4.1 (-1.2)	6.2 (1.8)
Tundra-barren	-3.1 (-1.4)	3.7 (1.7)	-3.2 (-1.1)	9.6 (3.5)
Water	-1.4 (-1.6)	2.8 (3.3)	-2.5 (-1.1)	11.8 (5.3)
Snow-ice	-5.4 (-2.0)	9.0 (3.3)	-4.1 (-1.6)	10.8 (4.2)



FLASHFLUX: Schematic Mapping to Current Example Uses

